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A CONCEPTUAL DATABASE DESIGN
OF A NAVAL SHORE COMMAND
MANAGEMENT INFORMATION SYSTEM

by

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As the Navy changes to meet different world situations, the need for administrative and management information within a shore command has increased. Most shore commands have attempted to meet this need with single-user relational databases. Often these databases are poorly designed and incorrectly implemented.

This project uses the enhanced entity relationship model to create a conceptual design for an administrative database. This basic model can be customized to fit the needs of a shore command. Fleet Numerical Oceanography Center, Monterey, CA was used to represent a typical mid-sized shore command to develop the basic model and prototype.

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A Conceptual Database Design
of a Naval Shore Command
Management Information System

by

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ABSTRACT

This thesis explores the creation of a conceptual design for a database that would assist any Naval shore command with its internal information needs. The database is intended to be a multi-user database accessed via a local area network (LAN). The thesis examines the administration and information needs of the command as an interrelated whole rather than as individual division and departments.

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I. INTRODUCTION

This thesis explores the creation of a conceptual design for a multi-user relational database that would serve any Naval shore command with its internal information needs via a local area network. The thesis examines the administration and information needs of the command as an interrelated whole rather than individual division and departments.

A. BACKGROUND

1. Historical Perspective

The Navy has been using computers and developing applications for many years to support its operational mission. There are a variety of computers and software used in weapons systems, simulators, accounting and payroll. Traditionally the *internal administration* and management of a command, however, have received very little automated data processing (ADP) support. These internal management functions consume a large portion of a manager's time. The officers and senior civil service personnel spend valuable hours tracking down such things as purchase requests or personnel information.

When the Navy's Z-248 micro-computer contract became available, personal computers and commercial off-the-shelf software (COTS) began appearing throughout shore commands. Managers immediately recognized the potential of word processing on microcomputers to relieve the overwhelming paperwork encountered each day. Navy

personnel began developing small applications beyond word processing by taking advantage of COTS spreadsheets, graphic programs and database management systems available from the Z-248 contract.

2. The Problem

One piece of software that was purchased with the Z-248 PC contract was a relational database management software package [Ref. 1:pp. 135-148]. Numerous databases were developed by personnel who had little or no expertise with database design. Examination of these databases shows there is very little design or user documentation available. The databases are not normalized [Ref. 1:p.373]. Many users feel the applications are awkward to use and inaccurate. Often, only the developer of the database can actually use the application. While information may be lost each time a personnel turnover occurs, these databases fill an immediate need for more effective control of information within the command.

Personnel in the command find these databases frustrating. The databases are rarely accurate and require too much effort to maintain. Check-in/check-out procedures illustrate the number of duplicate databases maintained within the command. When new sailors report to the command, they are given a check-in sheet with 10 to 15 different individuals or divisions they must visit. At each location the sailor repeats personal data. For example, names, social security numbers and home phone numbers might be retained by the administration officer, the department head, the division officer, the security officer, the master chief petty officer of the command and the command duty officer.

At most of these sites a database residing on a personal computer is used to record the sailor's arrival.

Upon the sailor's departure the process is reversed, except now each person on the check-out sheet attempts to determine if the individual has any outstanding action items requiring clearance before the sailor's departure. Have they returned all government property? Have they turned in their access badges? Each division then modifies their database to record the individual's departure.

These processes make check-in and check-out one of the most dreaded aspects of a transfer. Because check-in and check-out are so frustrating, individuals often attempt to circumvent the process. A sailor visits only those sites deemed in their best interest to notify of their arrival or departure. It is not unusual for different divisions in a command to have widely different databases concerning the personnel assigned to the command.

A sophisticated command recognizes the problem of unsychronized databases and creates elaborate administrative procedures to ensure the critical databases are kept synchronized. Data may be transferred by paper report or on floppy disk between the divisions. While this eliminates the problem of unsynchronized data, the data is usually late and the intricate administrative procedures are too complex to be performed correctly.

We propose that one multi-user database be maintained at a command and each of the various departments and divisions have access to the information they need. This was impossible a few years ago since most shore commands did not have any type

of computer network accessible by different people in different locations. If a command had a multi-user computer network it's primary purpose was certainly not for the administration and management of the command. Now, the availability of personal computers, LAN technology and inexpensive multi-user relational database software make this proposal feasible.

3. Local Area Networks

Local area networks combine the benefits of a personal computer with those of a multi-user system. A LAN allows users to communicate with one another and access a multi-user database. Data can be transferred to an individual's personal computer for further manipulation. A LAN also allows expensive hardware and software to be shared among many users.

As LAN technology became less expensive it became more commonplace. Many large and mid-sized Naval shore commands have invested in LANs, originally to share expensive resources; they are now beginning to see the benefits of using the LAN to quickly develop shared relational databases. There are many inexpensive COTS database management packages on the market to help managers build relational databases which meet their requirements.

B. RESEARCH QUESTIONS

The purpose of this study is to answer three research questions concerning the design and implementation of a Naval shore command administrative and management relational database:

- Which management functions of a Naval shore command are suited for implementation in a multi-user, relational database?
- Can a generic, conceptual database model be designed to meet the needs of any Naval shore command?
- What are the potential benefits of implementing such a database?

C. METHODOLOGY

The Fleet Numerical Oceanography Center (FLENUMOCEANCEN) in Monterey, CA volunteered to serve as a test-bed for this research. FLENUMOCEANCEN is a command of approximately 350 military and civil service employees. There are also a number of contractors that work at FLENUMOCEANCFN facilities. FLENUMOCEANCEN has a traditional chain of command structure with a commanding officer (CO), an executive officer (XO), department heads and division officers.

Information for this thesis was collected by interviewing all department heads, many division officers, and personnel currently responsible for maintaining or updating the command's existing databases. Existing databases were examined to determine the merits and demerits of the data maintained. No attempt was made to convert the application code of their systems.

Chapter II examines the data and functional requirements of this project. Chapter III contains a brief discussion of the conceptual design model used for this project and Chapter IV discusses the model developed during this project. Chapter V considers some security and administrative requirements for implementation of a database. Chapter VI

reviews the prototype database developed for FLENUMOCEANCEN and Chapter VII concludes this thesis.

II. DATA REQUIREMENTS

This chapter discusses the administrative information needs at FLENUMOCEANCEN. Interviews and existing single-user database systems were used to help categorize the information needs. The personnel also discussed their concerns regarding the implementation of a multi-user database.

A. INFORMATION NEEDS

1. The Managers

The managers at FLENUMOCEANCEN had two distinct requirements for their command information management system. First, they had a list of routine items on which they wanted up-to-the-minute information. These items centered on budget status and equipment accountability (plant property). The managers were easily able to describe these information requirements.

The second requirement was the need for information to meet future management changes. The Navy is changing drastically and rapidly and it is difficult to anticipate what that information would be. The biggest area of change is the budget process within with the Department of Defense's (DOD) current financial management system. The budget process procures money for the Department of Defense from Congress, and determines a command's fiscal processes and policies. If the budget process is changed, a new set of procedures is required.

Not knowing the future, most managers agree they need a database containing information concerning the daily operations of FLENUMOCEANCEN and the work output production. This data will be manipulated as required to develop information concerning the real costs of operating FLENUMOCEANCEN and producing work outputs. The managers desired an easy-to-learn ad hoc query language such as Structured Query Language (SQL) [Ref. 1:pp. 175-205]. Many managers are already familiar with the capabilities of SQL and feel a brief training course is all they need to become productive.

2. The Employees

The needs of the employees are different from the managers. They want help coping with their daily tasks. There was much discussion concerning the possibility of eliminating the paperwork flow between departments and divisions. Where paperwork could not be eliminated, they want assistance filling out the forms. The employees want reference information on-line allowing copies of reports and instructions to be discarded.

The employees also feel they can benefit from the flexibility of SQL. While they do not envision using SQL frequently for the performance of daily tasks, they felt managers should retrieve information themselves, thereby freeing the employees from some time-consuming research tasks.

The third requirement of the employees is the most critical. The database and applications have to provide positive feedback. Several existing database systems do not provide any feedback--transactions are entered into the database and disappear.

Employees maintain two set of records, one on the computer and a second in a log book. Any developed system must be accepted by the employees as efficient.

B. THE INTERVIEWS

After the first few interviews, it was obvious the personnel at FLENUMOCEANCEN had varying degrees of knowledge of computer systems in general and databases in particular. A brief tutorial was prepared to help educate these personnel. The tutorial contained an example of a check-in process and a description of the data modeling process. Entity relationship diagrams and relational schema diagrams were explained. The tutorial was distributed to personnel before their interview.

Some personnel required more than one interview. The first interview was spent reviewing the tutorial and generating some starting points. The succeeding interviews were used to gather ideas and requirements for this project.

FLENUMOCEANCEN personnel were excited by the idea of sharing information between divisions. The best ideas concerning a department frequently came from outside the department. Department personnel were surprised to discover their contemporaries felt their department was providing untimely information.

There was also concern about the ability of appropriate security procedures protecting privacy act and sensitive data. These concerns determined if an administrative or management function would be included in the database.

C. EXISTING DATABASES

Many areas considered for this project have some form of single user database already in operation. The most popular is personnel, accounting and plant property databases. Several other databases are maintained in spreadsheets and word processors.

FLENUMOCEANCEN established standardized COTS packages for employee use. The administrative databases use dBASE[1] IV software. Lotus 1-2-3[2] is the spreadsheet software and Wordstar[3] is used for word processing. FLENUMOCEANCEN recently implemented a LAN and a calendar package containing information concerning employees' daily schedules. Typical of most shore commands, FLENUMOCEANCEN is experiencing problems with the current systems. The databases were developed by individuals who had little formal or practical training in database design. Often, the original programmer had transferred and current personnel are "stuck" with a system which only partially meets their needs. None of the databases are designed to be shared on a LAN.

The focus in these early databases was on the application rather than on the data. Some of these relational databases do not meet the requirement of the first normal form [Ref. 1:p. 373], which is the minimum format required to categorize a database as relational. Many older systems began as dBASE II databases and were "patched up" as each succeeding version of dBASE was released.

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[1]dBASE is a registered trademark of Borland International, Inc.

[2]Lotus 1-2-3 is a registered trademark of Lotus Development Corporation.

[3]Wordstar is a registered trademark of Wordstar International.

While there are many problems with the existing databases, it is important to note these databases met an important need when developed. They provided information to someone who needed it. In the short-run they were very useful.

D. FUNCTIONAL AREAS

Almost every administrative and operational function is proposed for inclusion in the database. Two criteria are established to control the scope of the database. First, the data has to be something of interest to more than one department. Second, the data must have a sponsor--someone willing to maintain the data. The first criteria is occasionally relaxed when collecting data required for a replacement financial management system.

The following areas are included in the database design:

- Personnel: employees, training, visitors, awards, security access, work schedules, employee qualifications, employee specialties/resources
- General administration: correspondence, logs, instructions, plans of the week, plans of action
- Property and facilities: major property, minor property, other property (manuals, tapes, etc.), buildings, work requests
- Financial management: contractors, customers, products, budgets, supplies, inventories

These functions are chosen for their concern to most shore commands with the possible exception of the contractor area. The data in these areas are of interest to more than one department and currently being maintained by someone in the command.

Several areas are not included. The first area is categorized as not of general interest in the command. The second area contains personnel data such as punitive records. This information is considered too sensitive to contain in this type of COTS, multi-user database.

An additional concern is the legal requirement to obtain a signature on documents. Any document requiring a signature can be augmented with the database, but not replaced. For example, FLENUMOCEANCEN uses a locally designed work sheet to begin processing travel orders. This work sheet could be eliminated and replaced with a travel application in the database. The database could then prepare the actual travel orders requiring appropriate signature for completion.

III. THE DESIGN AND IMPLEMENTATION MODELS

This chapter briefly discusses the advantages of the enhanced entity relationship (EER) model as a database design model and gives steps necessary to convert the EER model to the relational model for implementation.

A. THE ENHANCED ENTITY RELATIONSHIP MODEL

The enhanced entity relationship model [Ref 1:p. 410] was chosen as the design model. The EER model is a high-level conceptual data model. This model allows a great deal of information to be displayed in an enhanced entity relationship diagram (EERD). These diagrams can be used by the database designer and the users to diagram the mini-world being considered. The EER model is not an implementation model. There are no commercial database products available which implement the EER model directly [Ref. 1:p. 37].

To illustrate the flexibility of the EER model and diagram, consider figure 1, a mini-world where shore commands may hire employees. Employees must work for some shore command, but only one. Each employee must be assigned a billet. The employees must be either civil service employees or military employees. The shore command has a name, a unit identification code (UIC) and a commanding officer. Each UIC and commanding officer is unique. Each employee has a last name, a unique social security number (SSN) and one or more office phone numbers. Civil service employees have a

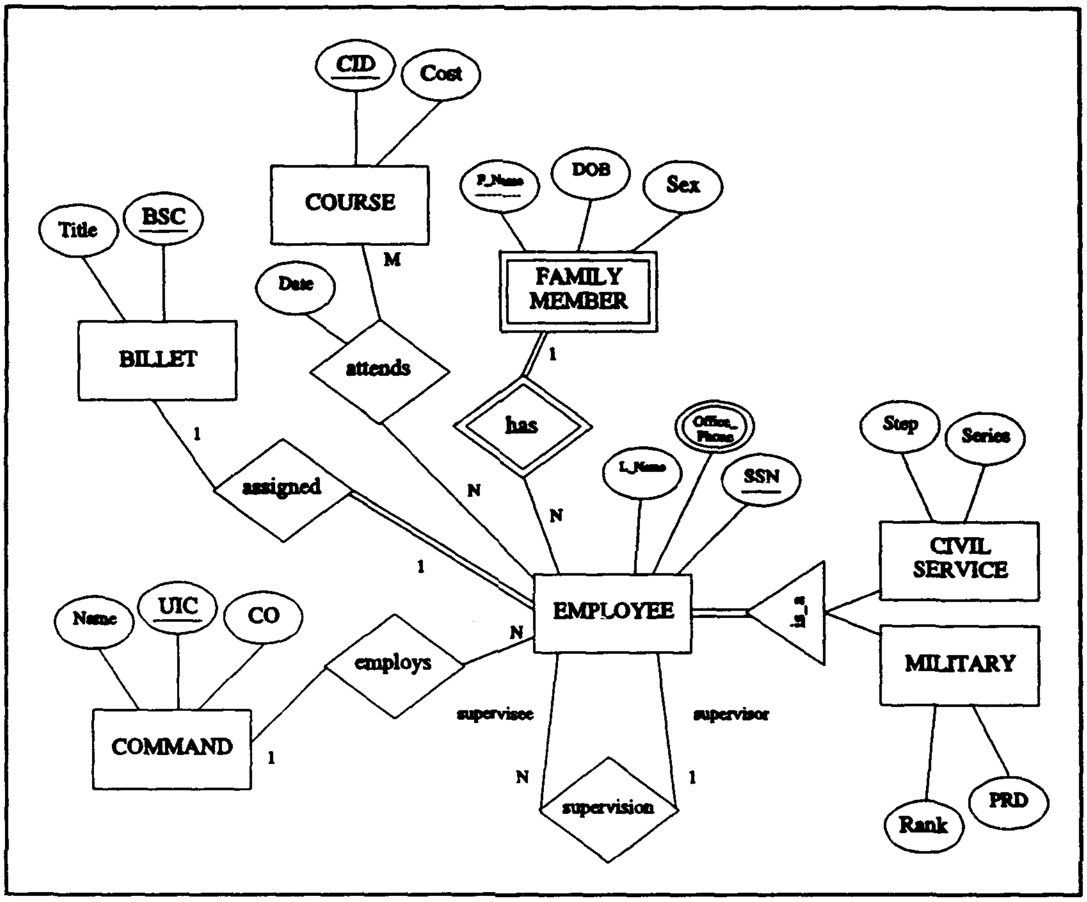

Figure 1. EER Diagrams: An Example

civil service series number and a grade/step. Military members have a rank and a planned rotation date (PRD). A billet has a unique billet sequence code (BSC) and a title. Each employee may have several family members. The family member has a first name, a date of birth (DOB) and a sex. Each employee is supervised by another employee. Employees may attend training courses. Each course is attended by several employees. Courses have an identification code and a cost.

Figure 2 contains the symbols used in EER diagram construction [Ref. 1:pp. 57, 412]. While the EERD may be intuitive to most users, the following definitions may be helpful to correctly interpret the EERD:

- Entity type: a group of things in the real world with an independent existence [Ref 1: p. 40]. Examples of entities are COMMAND and EMPLOYEE. Entity types are represented by rectangles.

- Weak Entity Type: an entity type without a key attribute of its own [Ref. 1: p. 52]. The FAMILY MEMBER entity type is a weak entity type in figure 1. Weak entity types are represented by double rectangles. The weak entity type only has a partial key, the primary key of the owner entity type is also needed. The partial key is represented by a dashed underscore.

- Attribute: "a property of the entity describing the entity" [Ref 1: p. 40]. Examples of simple attributes for the EMPLOYEE entity are last name, social security number and office phone number. A key attribute is an attribute or a group of attributes uniquely identifying each entity. Attributes are represented by ovals. Key attributes are represented by a solid underscore. Partial keys are represented by a dashed underscore.

- Multi-Valued Attribute: an attribute having multiple values for a single entity [Ref 1:p. 41]. The attribute office phone number might be multi-valued if there is more than one number available to an office. Multi-valued attributes are represented by double ovals.

- Relationship type: "a set of associations among entities" [Ref 1:p. 46]. A command employs employees. The COMMAND entity is related to the EMPLOYEE entity through the employs relationship. Relationship types are usually described with verbs. Relationship types are represented by diamonds.

- Identifying Relationship: a relationship type used to link a weak entity type to its owner [Ref. 1:p. 52] The has_family relationship type is an identifying relationship in figure 1. Identifying relationships-types are represented by double diamonds.

- Recursive Relationship: a relationship where an entity type participates in a relationship more than once in different roles [Ref. 1:p. 49] The supervision relationship is recursive. An employee is supervised by another employee. A

recursive relationship type can be recognized by the "circle" from the entity type to the relationship type back to the original entity type.

- ISA Relationship: a special relationship for creating subclasses of entities [Ref 1:p. 410]. The EMPLOYEE entity type is the superclass. Each employee is either a civil service employee or a military employee. CIVIL SERVICE and MILITARY are subclasses. An ISA relationship type is represented by a triangle.

- Participation Constraint: "the existence of an entity depends on its being related to another entity via the relationship type" [Ref. 1:p. 50]. In figure 1, EMPLOYEE participates totally in the employs relationship. Every employee must be employed by a command. The COMMAND entity only participates partially in the relationship. Each command may not employ employees. Partial participation is represented by a single line between the entity type and the relationship type; total participation is represented by a double line.

- Cardinality Ratio: "the number of relationship instances that an entity can participate in" [Ref. 1:p. 50]. The three types are one-to-one (1:1), one-to-many (1:N) and many-to-many (M:N). In figure 1, the COMMAND:EMPLOYEE relationship is an example of a 1:N relationship. One command may employ many employees. An example of a 1:1 relationship is EMPLOYEE:BILLET. One employee is assigned to one billet. COURSE:EMPLOYEE is an example of a M:N relationship. A course is taken by many employees and employees take many courses.

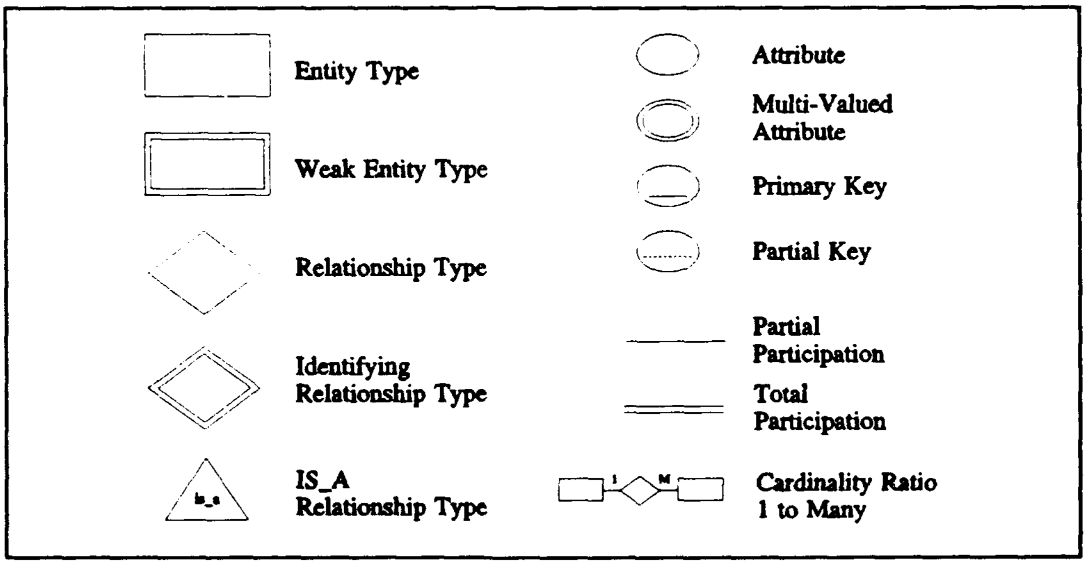

Figure 2. EER Diagram Notation

B. THE RELATIONAL MODEL

Since the EER model is not currently available as a COTS product, it is necessary to translate or map the EER model to an implementation model. The relational model was chosen for this project because of its flexibility, availability and cost. One of the benefits of the EER model is that it can be mapped quickly and easily to the relational model. Figures 3 and 4 illustrate the mapping process. There are eight steps to the mapping process [Ref. 1:pp. 329-331, 427-428]:

- Step 1: For each regular entity type, create a relation containing all the simple attributes of the entity type. Assign a unique attribute or unique group of attributes as the primary key. Underscore the primary key. Identify any other attributes which could serve as candidate keys (c.k.). Figure 3, step 1 shows four relations, COMMAND, EMPLOYEE, BILLET and COURSE that were created.

- Step 2: For each weak entity type, create a relation containing all the simple attributes of the entity type. Also include as a foreign key (f.k.), the key attribute(s) of the owner entity type. Figure 3, step 2 shows the addition of the FAMILY_MEMBER relation with the inclusion of the SSN attribute from the EMPLOYEE relation.

- Step 3: For each binary 1:1 relationship, identify the two relationships involved and add the primary key of one relation as a foreign key in the other. Figure 3, step 3 shows that the SSN attribute from EMPLOYEE was included in the BILLET relation.

- Step 4: For each non-weak binary 1:N relationship, identify the relationship on the 1 side and include its primary key as a foreign key in the relationship on the N side. Figure 3, step 4 shows the UIC attribute from the COMMAND relationship included in the EMPLOYEE relation. *Since the supervision relationship* is recursive, the EMPLOYEE relation also includes a new attribute called Boss_SSN which represents the supervisor's SSN as a foreign key which refers back to the SSN in the same EMPLOYEE relation.

- Step 5: For each binary M:N relationship, create a new relation and include the primary keys from both of the relations in the new relation. Also include any attributes of the relationship in the new relation. In figure 3, step 5 the new

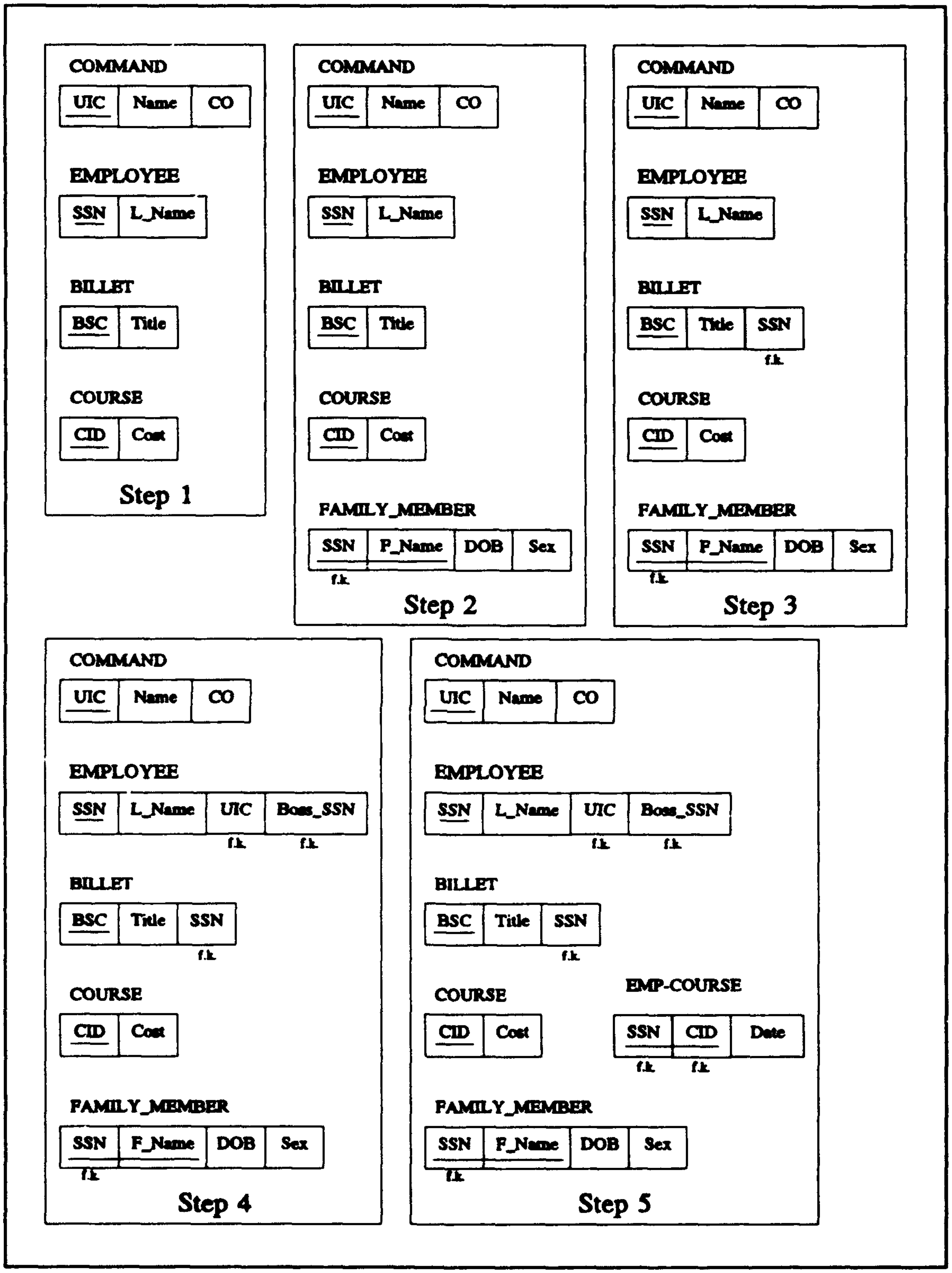

Figure 3. EER-to-Relational Mapping

relation EMP-COURSE is created. It's primary key is the combination of the SSN and CID attributes from the EMPLOYEE and COURSE relations. The attribute Date was added to the new relation.

- Step 6: For each multi-valued attribute, create a new relation including the primary key of the entity and the multi-valued attribute. In figure 4, step 6 a new relation EMP-PHONE was created with the attributes Office_Phone and SSN. The primary key for the EMP-PHONE relation is a combination of both attributes.

- Step 7: For each n-ary relationship, create a new relationship and include as foreign keys the primary keys of each relation in the n-ary relationship. This step is not necessary in this example because this mini-world does not contain a relationship with more than two entity types participating.

- Step 8: For each subclass ISA entity, create a relation and include as the foreign and primary key, the primary key of the superclass entity type. In figure 4, step 8 the CIVIL_SERVICE and MILITARY relations were created.

Elmasri and Navathe [Ref. 1:pp. 427-428] propose several different options for completing step 8. The method used in step 8 of this example provides relations that duplicate only the primary key in the relations representing the subclass entity types. The other options duplicate more than just the primary key or result in relations having many empty attributes. This option is appropriate for this type of superclass/subclass relationship type [Ref. 1:p. 428].

Upon completion of these eight steps, the relations are in the 1st normal form (1NF) of the relational model [Ref. 1:p. 373]. Normalization is "The process of determining the correct location and function for each attribute in order to correctly formulate the relational schema." [Ref. 2:p. 56] While eight normal forms are defined for the relational model, it is not always necessary or desirable to normalize to the highest possible form [Ref. 1:pp. 372]. The higher normal forms are difficult to

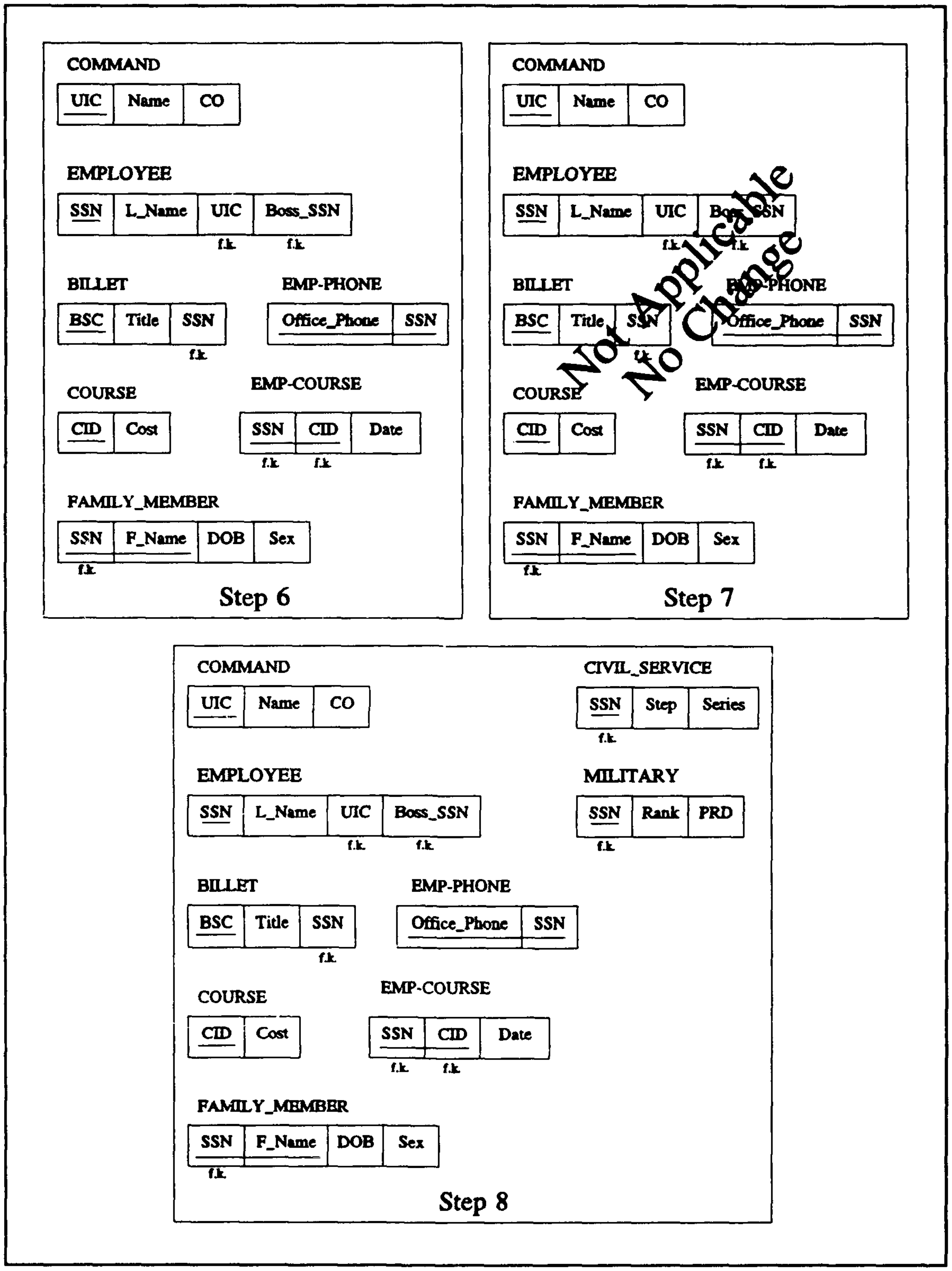

Figure 4. EER-to-Relational Mapping Continued

understand and divide the database into many small relations causing serious performance problems. The fourth level, Boyce-Codd Normal Form (BCNF) is considered a good compromise [Ref. 1:p. 372]. The example in step 8 of figure 3 also happens to be in BCNF, without any additional work.

IV. THE BASIC MODEL

This chapter presents the EER model created during this project. The chapter outlines the refinement process and discusses methods to modify the model for implementation at different commands.

A. THE CONCEPTUAL SCHEMA DESIGN PROCESS

After the interviews and review of the existing systems, an initial EER model was created. The model underwent a refining process resulting in the model contained in Appendix A. When looking at the command as a whole, it became obvious that entity types, considered unique by division personnel, were in fact minor variations of one entity type. For example, the office supplies, the PC software supplies and the spare parts inventory were all condensed into the INVENTORY entity type. This first major refinement involved consolidating these separate entity types into broader entity types. This process cut the number of entity types by approximately 30 percent.

At this point, the model had three main focal points. The EMPLOYEE, ORGANIZATION and BUDGET entity types were hubs around which the other entity types were arrayed. A fourth area, general administration, did not have a hub but was a recognizable group about the ORGANIZATION entity type.

After the initial refinement, the model was reviewed by FLENUMOCEANCEN representatives and officers that had served at different types of Naval shore commands.

It became obvious that the model did not adequately represent commands other than FLENUMOCEANCEN. To make the model functional for other commands, it was necessary to remove many of the relationship types between the entity types. For example, at some commands an employee may not attend a training course unless the course is listed on the employee's individual development plan (IDP). This would create a ternary relationship between EMPLOYEE, COURSE and INDIVIDUAL DEVELOPMENT PLAN. At other commands, the IDP is only a guiding document and is not meant to restrict an employee's course selection.

This second refinement reduced the number of relationship types by 40 percent. The resulting model lost its BUDGET hub and was converted to a broad area concerning the fiscal management activities of a command. The ORGANIZATION and EMPLOYEE hubs remained.

B. THE BASIC MODEL

The refinement process created a model minimally acceptable to all the representatives but insufficient to meet any one representative's needs. The fiscal area created the most dissension among the officers. The financial management of a command is guided by many regulations but each command has implemented varying procedures and policies for complying with these regulations. For example, the PHONE_CALL entity type represents the long-distance phone calls made by the organization's employees. These calls must be accounted for upon receipt of the phone bill. At some commands each phone call is considered an expenditure against the

department's budget, thereby creating a relationship between PHONE_CALL and EXPENDITURE. However, at large commands, the phone calls are certified by the department, but are paid out of a central account whose budget is not retained at the lower level.

The differences in procedures could usually be traced to the size of the command. The large shore commands have a high percentage of civilian personnel and non-traditional chain of command structures. At these commands, the loosest form of the model is necessary. At the smaller commands with a traditional chain of command structure, a tighter model may be implemented. None of the representatives agree upon the different attributes which should be associated with each entity type.

The basic model is diagrammed in figures 6 through 7 in Appendix A. The model is divided into four sections following the four general functional areas:

- Section 1: Personnel
- Section 2: Facilities and property
- Section 3: Financial management
- Section 4: General administration

Appendix B is a data dictionary containing an alphabetical list of the entity types and a brief description of the entity types.

C. CUSTOMIZING THE MODEL

The basic model may be mapped to the relational model for implementation. The basic model is very "loose" and represents those commands having a non-traditional chain of command structure. The traditional responsibilities of the commanding officer in this type of command are delegated to several individuals due to the size of the command. This structure is typical of the large commands in Washington, Norfolk, San Diego, Pearl Harbor, etc. The divisions in these commands may contain several hundred people and are usually divided into smaller units for daily operations. These very large commands require the most flexible model for their database. The database is most useful at the smaller working group level.

A medium-sized command with a traditional chain of command structure would benefit from a "tighter" version of the basic model. This command could modify the model to include more relationship types between the entity types such as the phone bill example above. Personalizing the model allows the command to accurately represent their particular situation.

Customizing the basic model involves four steps. First, examine the entity types and relationship types in the basic model. Do they generally match the procedures at your command? Make any changes as appropriate. Second, begin adding attributes to the entities. This may not be straightforward. For example, where would an office phone number attribute belong? Some commands have one phone number for each division and the attribute should belong to the ORGANIZATION entity type. Some commands have single-line phones in each office. In this case, the phone number

attribute would belong to the FACILITY entity type. At other commands, the phone number is stored in the phone itself. As personnel move from office-to-office they take their phone and phone number with them. The EMPLOYEE entity type should be used in this situation.

After the attributes are added, the third step is to review the model. Check each entity type and relationship type to ensure they accurately represent your situation. Fourth, add any additional relationship types to "tighten" the model. Consider the new relationship types carefully, for there is a trade-off. Additional relationship types may result in additional relations which will increase the complexity of the database and may decrease performance [Ref. 1:p. 372].

V. DATABASE ADMINISTRATION AND SECURITY CONSIDERATIONS

Chapter V discusses some of the policy and operational considerations that must be thought about before a multi-user database is implemented.

A. DATABASE ADMINISTRATOR FUNCTIONS

While this database is not exceptionally large, it will be used by personnel with varying degrees of database expertise. Once the database is complete it will be necessary for an individual or group to have database administrator (DBA) responsibilities. These responsibilities concern the smooth daily operation of the database. The DBA will be responsible for making backup copies of the database, granting access to the database and generally monitoring the database for problems.

The individual assigned the DBA responsibilities should be knowledgeable about database practices and procedures in general and with the capabilities of the relational database management system (RDBMS) used to implement the database. The DBA should interact easily with users from different departments and different levels in the chain of command. The DBA's position in the chain of command should allow the impartial performance of their duties.

The DBA responsibilities for this database should not require full-time personnel. The exact amount of time spent daily on the DBA functions will depend upon several variables. Initially, the procedures used to convert the old single-user databases to the

new database will have a dramatic affect on the time required to monitor the database. Old single-user applications "patched up" to function in the new system will require a great deal of DBA attention. Clean applications written by experienced personnel will require less intervention by the DBA.

The individual's database experience also will greatly affect the time needed to administrate the database, e.g., a knowledgeable individual might require only two hours a day to perform the DBA functions while a less experienced person may require four or more hours.

B. DATABASE SECURITY

The security of the database is one topic that all the interviewees could agree upon. The personnel data contained in the database is subject to privacy act restrictions and the financial management data is sensitive. Much of the data could be made available for general viewing by employees, but modification and deletion of the data is restricted.

The security features of the database depend primarily upon the RDBMS package. COTS packages vary widely in capabilities. Access to data can be controlled through the multi-level applications development, but will not affect the individuals who have access to the data manipulation language, such as SQL.

First, the RDBMS should have a user identification and password system. The Department of Defense and the Department of the Navy (DON) have extensive and explicit requirements for password systems [Ref. 3]. These regulations are usually

supplemented by local command policy. The RDBMS should support all levels of regulations and policies.

Second, the RDBMS security system should allow the DBA to restrict access to the database by table, column and row. The restrictions should include insert, modify, delete and view functions. For example, all users should have view access to the plan of the week. Only certain users might be allowed to insert new budget items while other users may be allowed to modify the cost attribute for the item. The combinations of access to the various entities are large and require the command to make some policy decisions.

Third, the database should have a mechanism for back-tracking transactions and "rolling back" the database in case of problems [Ref. 1:p. 542]. Each transaction must be traced to a specific user.

Fourth, the database files should be protected. If a user can access the files from the operating system, the first three security procedures are useless. Many COTS RDBMS packages store the database in easy-to-access ASCII format.

Another area for consideration is the relationship between the RDBMS security and the network security. Perhaps the network can pass user identifications and passwords to the DBMS. This may supplement the existing system by providing another layer of security.

VI. PROTOTYPE

Chapter VI provides an overview of the single-user prototype developed as part of this project. Positive and negative aspects of the database management system software are discussed.

A. THE DATABASE MANAGEMENT SYSTEM

R:BASE 3.1C[4] from Microrim was used to implement the prototype. R:BASE 3.1C was chosen because it meets the American National Standards Institute (ANSI) Level 2 SQL standard [Ref. 4:p. 321]. It is readily available on the commercial market, though it is not as widely known as some other RDBMS packages. R:BASE can be implemented for multiple users on a LAN but the prototype was developed only for a single-user.

R:BASE 3.1C also contains several features that make it an excellent choice for this prototype. It contains a data dictionary and an extensive set of aggregate functions not included in the SQL standard. R:BASE 3.1C has transaction processing and rollback features. The screen and report generators are easy to use and sophisticated.

R:BASE 3.1C uses SQL to create rules regulating data entry in the database [Ref. 4:pp. 256-260]. These rules are variations of the SQL select command [Ref. 1:p. 178]. For example, if the database contains a table called STATES of the 50 state abbreviation

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[4]R:BASE is a registered trademark of Microrim, Inc.

codes and a table called CUSTOMER where customer addresses are entered, the paraphrased rule would say, "Add the row to CUSTOMER if the customer's state code is in STATES." The flexibility of SQL allows the creation of very complex rules to help maintain the integrity of the database.

B. PROTOTYPE FUNCTIONS

Appendix C contains an EERD of the prototype. The organization and personnel hubs were chosen as the basic starting points for the prototype. Most of the personnel and general administration areas that were included in the prototype were chosen because they did not currently have any automated support. Their inclusion was needed to help those users envision the possibilities of full implementation. The property area was included because all the department heads felt it needed immediate attention.

The developed applications were very basic. The ability to add, edit and delete records using an intuitive menu system was the primary function. The reports developed included listing of property, personnel recall bills, plans of action and distribution labels for incoming correspondence.

C. ASSIMILATING EXISTING DATA

Whenever possible, data from existing databases were incorporated into the prototype. The existing data was contained in dBASE IV, Lotus 1-2-3 and various word processors. Each of these programs could output the data to an ASCII file. If the data needed drastic manipulation, it was imported to a word processor, edited and output again to an ASCII file. R:BASE does not store the data in separate ASCII files but

contains an import feature [Ref. 5:p. 8-25] that allowed the data to be loaded into the database.

D. LESSONS LEARNED

R:BASE provided an excellent tool for developing the prototype database. The database was created in only one hour while the applications required approximately 25 hours. The screen and report generators were outstanding. The data dictionary was useful but limited in the amount of space allowed for descriptions.

The R:BASE security system could control access to tables and columns, but not to rows. This means if all the departments' budgets are stored in one table with an attribute to identify the department, there is no way to use this attribute to restrict a department head from accessing other departments' budgets unless it is through an application program.

R:BASE can only link a maximum of five tables when creating a view. There was a noticeable delay in response time when SQL was used to join more than three tables in a query.

An additional concern was the speed of the RDBMS. R:BASE's performance was unacceptable on a personal computer with an 80286 processor but provided a response time of two or three seconds with an 80386 processor. This might not be a concern on a multi-user system as it is unlikely that an 80286 processor would be used as a server.

VII. CONCLUSIONS

This project is considered the first step for developing the requirements in a multi-user relational database at FLENUMOCEANCEN that can be accessed via a LAN. This is the first time that the functional management relationships of the command have been viewed as a whole and the conceptual schema for a database designed for the command. The management functions outlined in section D of Chapter II are of concern to every shore command and are suited for implementation in a multi-user, relational database. Most commands will have additional functions that should be included, depending upon the command's mission. Almost any functional area can be included in the model. Areas containing extremely sensitive personnel data and classified data should not be included; or if included, must have the appropriate security system for the type of data [Ref. 3].

The model developed and displayed in Appendix A could be used by any command as a generic model for a database design, but to be truly effective, the model should be personalized for the command. Additional relationship types exist at most commands, especially in the financial management section of the model. Unfortunately, it is not possible to create one database and application system that could be used at all commands. The Naval Computer and Telecommunications Area Master Station Lant Detachment has created several products under the GENUS name that provide administrative functions. These products have mixed support in the shore community.

Some commands feel the GENUS products meet their needs while others do not like the procedures required by GENUS products.

Customizing the design may require creating additional entity types and relationship types. Attributes must be added to the design in the appropriate location for the command. Next the customized EER model is mapped to the relational model and normalized. The design is ready to be implemented in the RDBMS. This process will require the attention of a database design professional. While both the mapping process and the normalization process have step-by-step instructions, there are always occasions when a design decision must be made between two or more options. An experienced database designer can evaluate the options and choose the most effective one(s).

The primary benefit of a successful implementation of this project is the decrease in time spent on administrative matters and the availability of timely information to support quick response requirements. The need to support these requirements can be demonstrated by two programs that could dramatically affect a shore commands operations and require the Navy to consider the need for a generic relational administrative database design tailored to meet functional requirements [Ref. 6]. The first is the unit costing proposal under which a command would be provided a set amount of funding for every product it produces. A second proposal is the Defense Business Operating Fund (DBOF), which is a program where military commands operate as businesses and charge other commands for products and services. This is currently how the Industrial Fund activities, such as ship yards, operate. DBOF is currently being tested at several shore commands and might apply to all commands in the next few years.

Both of these initiatives will require a command to have access to its real costs and outputs. Implementation of DBOF will require sophisticated billing and accounting software while unit costing will require certification of outputs. This database design is the first step toward preparing for these initiatives.

The implementation of a multi-user, relational database will require the attention of a database administrator to function correctly. Experienced database administrators already have many demands placed upon their time. This database will be an additional burden. Another cost is the purchase of a sophisticated COTS package to implement the design and training of command personnel to use the COTS.

The basic model developed during this project is intended to provide a starting point for shore commands. The model can be used to evaluate COTS management information systems for their applicability to meet the Naval shore command's environmental requirements. Products that cannot provide this minimum functionality are ineffective and will not meet the needs of the command. A tailored model can be used to establish specifications and design requirements for the development a command's management information system.

APPENDIX A

THE BASIC ENHANCED ENTITY RELATIONSHIP MODEL

This appendix contains the basic enhanced entity relationship model developed during this thesis.

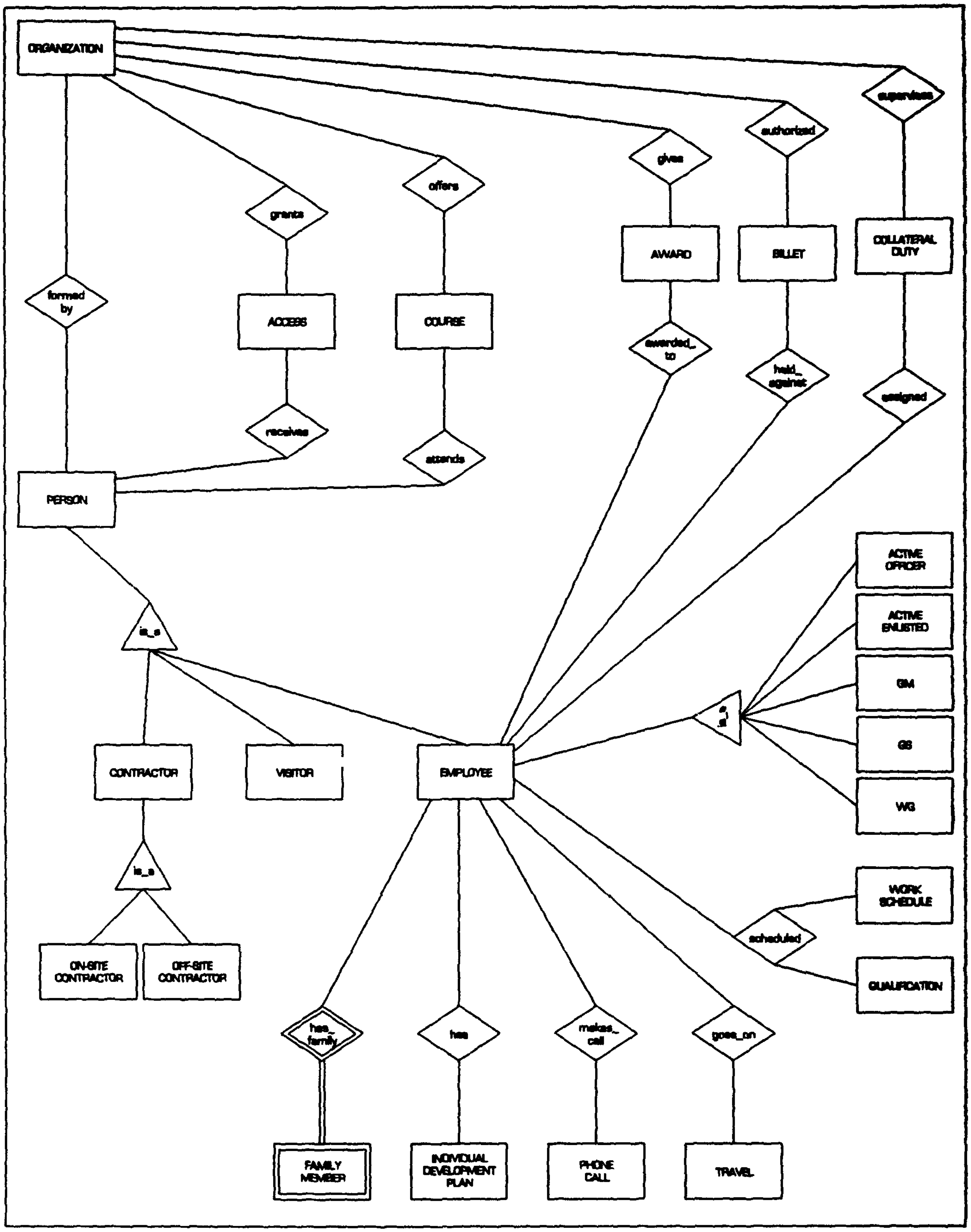

Figure 5. EERD Section 1

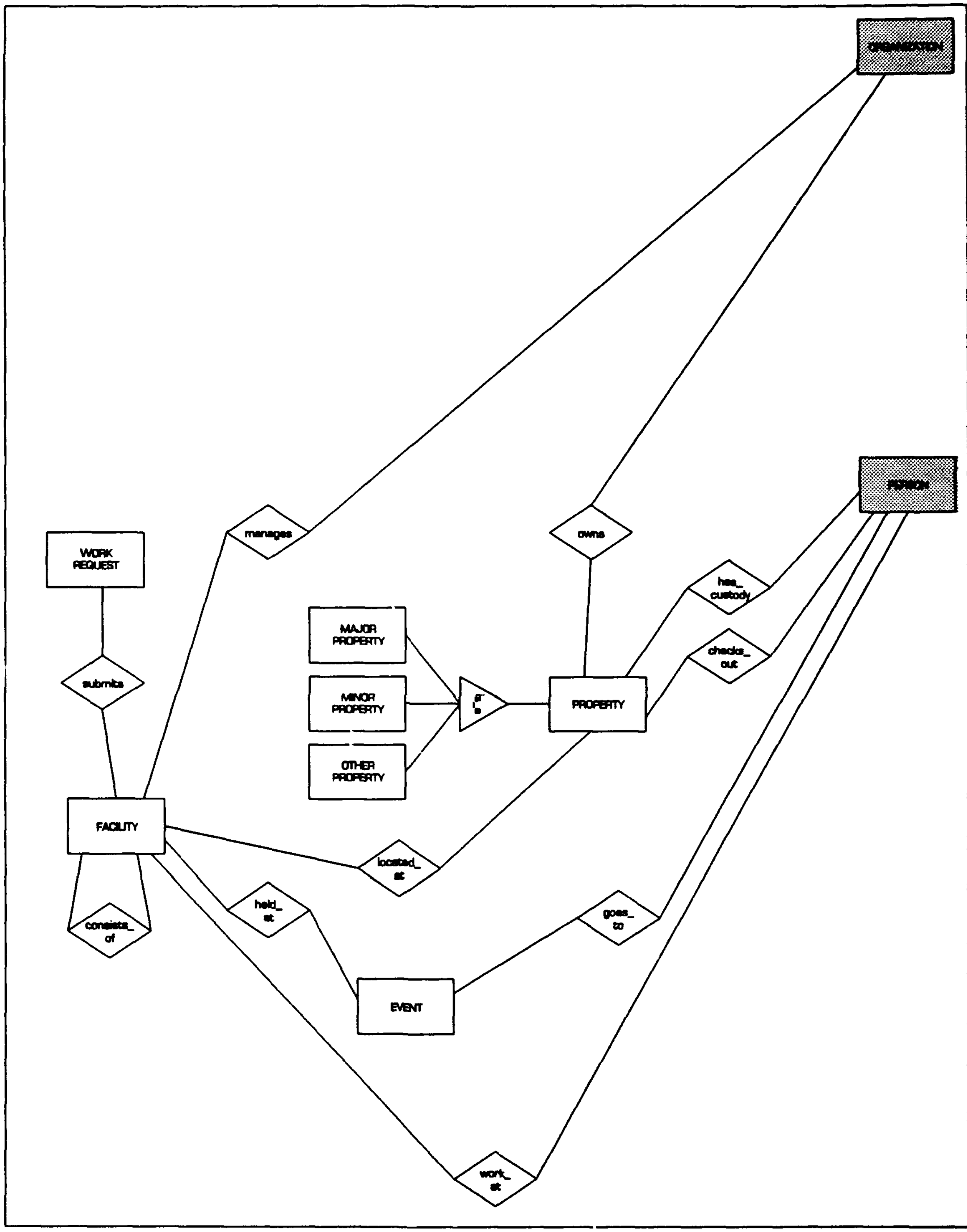

Figure 6. EERD Section 2

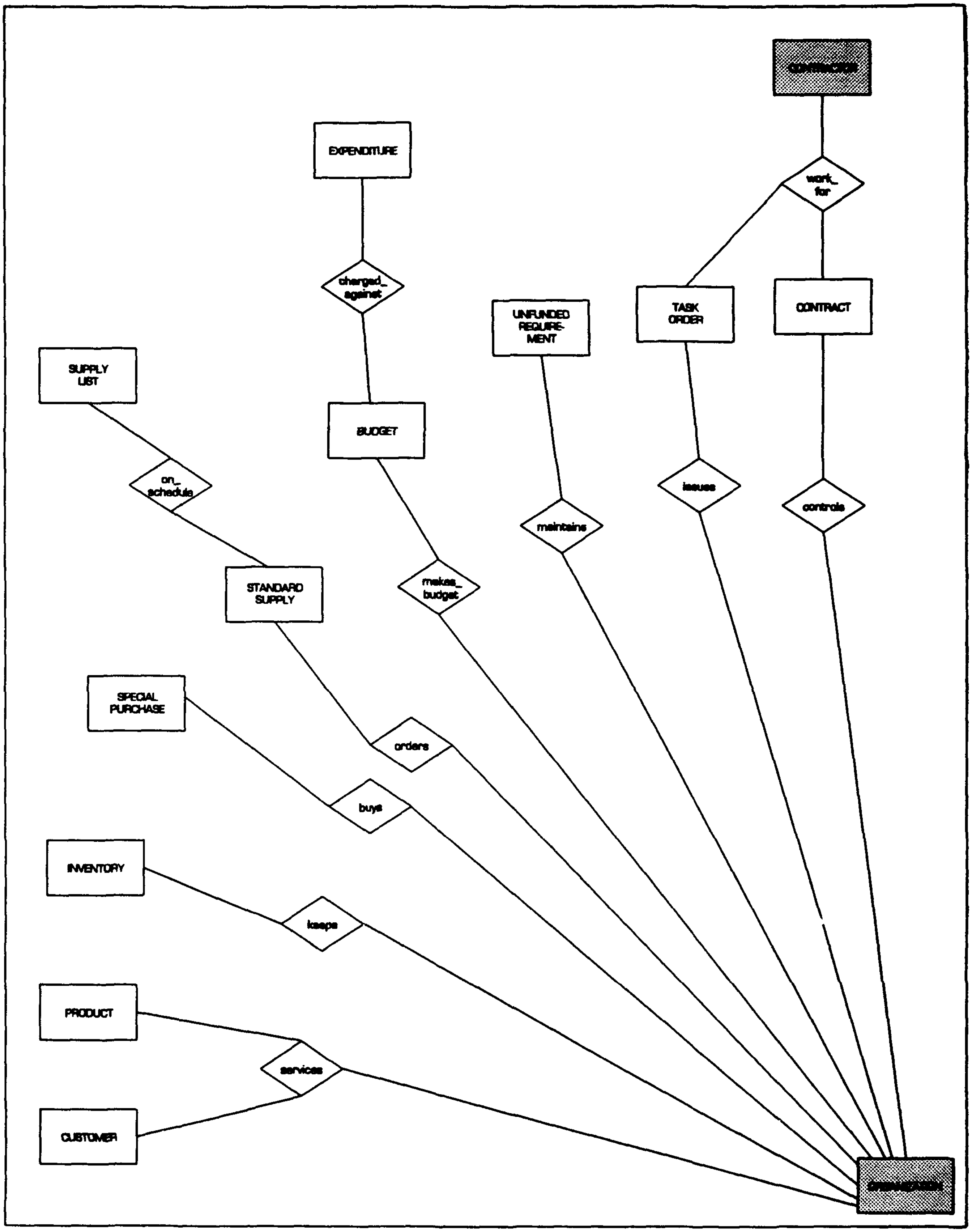

Figure 7. EERD Section 3

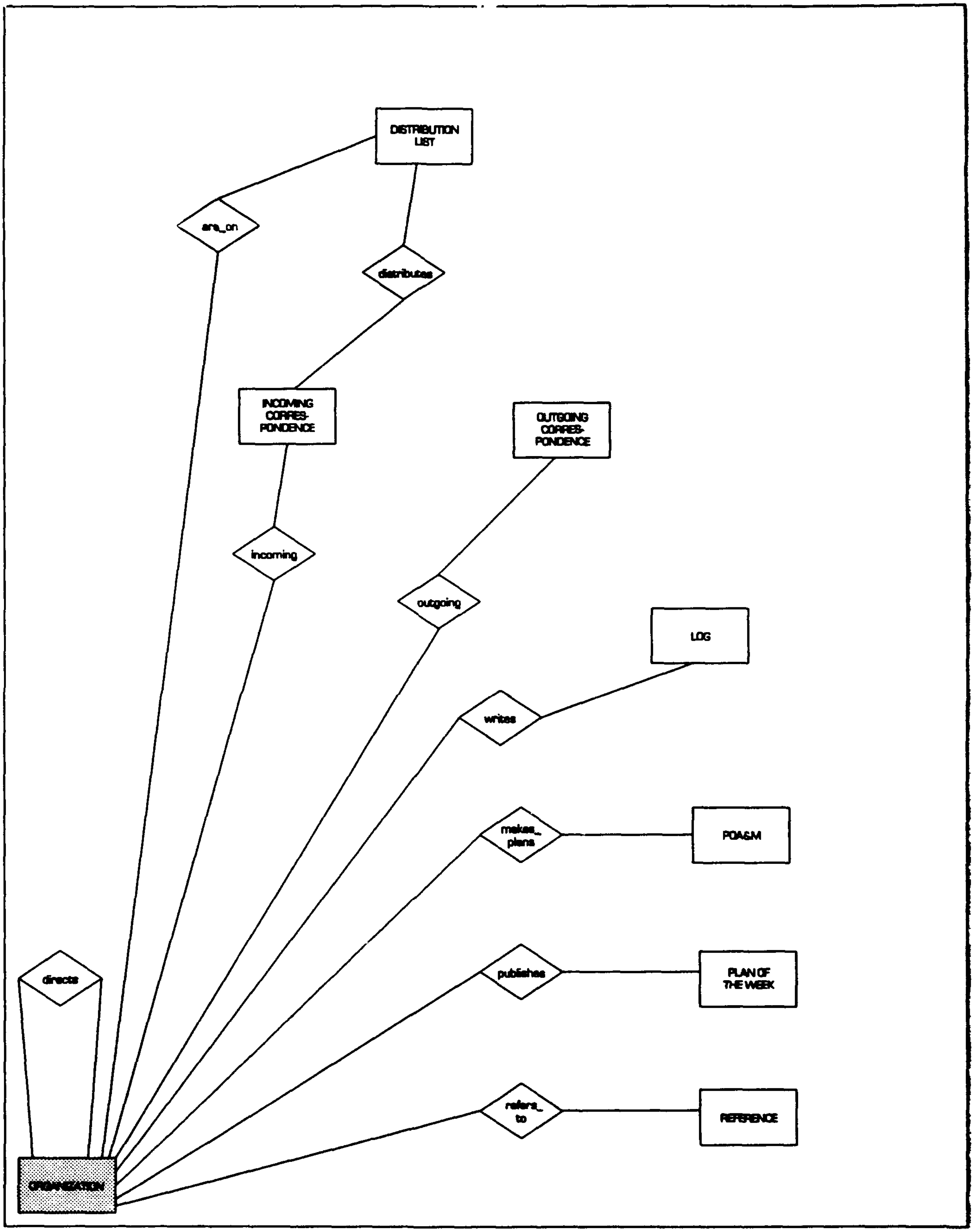

Figure 8. EERD Section 4

APPENDIX B

THE ENTITY TYPE DESCRIPTIONS

This appendix contains the descriptions of the entity types developed for the model in Appendix A. The entity type codes are R for regular, W for weak and S for subclass.

Entity Type Name	EERD Section	Entity Type	Description
ACCESS	1	R	A type of permission or authorization that might be granted to people. For example, authorization to drive military vehicles or individuals who may have access to a room or building.
ACTIVE ENLISTED	1	S	An EMPLOYEE who is an active duty enlisted member.
ACTIVE OFFICER	1	S	An EMPLOYEE who is an active duty officer.
AWARD	1	S	An award or recognition that may be given to an EMPLOYEE as a reward for outstanding performance.
BILLET	1	R	A specific civilian or military job or position.
BUDGET	3	R	The financial spending plan of a command.
COLLATERAL DUTY	1	R	An duty assignment given to an EMPLOYEE in addition to their traditional duties.
CONTRACT	4	R	A legal document used to purchase goods or services.
CONTRACTOR	1	S	A PERSON who is employed under a CONTRACT.
COURSE	1	R	A period of training.
CUSTOMER	3	R	Someone who receives service from the command.

Entity Type Name	EERD Section	Entity Type	Description
DISTRIBUTION LIST	4	R	A list of EMPLOYEEs who receive a piece of INCOMING CORRESPONDENCE based upon its topic.
EMPLOYEE	1	R	A military or civil service PERSON who works for the ORGANIZATION.
EVENT	2	R	A meeting or briefing.
EXPENDITURE	3	R	An expense incurred by the ORGANIZATION.
FACILITY	2	R	A base, building or room under the management of the ORGANIZATION.
FAMILY MEMBER	1	W	A member of an EMPLOYEE's family.
GM	1	S	A general management civil service EMPLOYEE.
GS	1	S	A general service civil service EMPLOYEE.
INCOMING CORRESPONDENCE	4	R	A piece of mail or message traffic received by the ORGANIZATION.
INDIVIDUAL DEVELOPMENT PLAN	1	R	A plan of short- and long-term goals for an EMPLOYEE. The plan usually contains a list of training COURSEs that the EMPLOYEE will take during the next year.
INVENTORY	3	R	A group of items held in storage until needed.
LOG	4	R	A list of events that transpired during a work shift.

Entity Type Name	EERD Section	Entity Type	Description
MAJOR PROPERTY	2	S	Property that is classified by regulation as major. Us. ally property that has a value greater than $5,000.
MINOR PROPERTY	2	S	Property that is classified by regulation and policy as minor.
OFF-SITE CONTRACTOR	1	S	A CONTRACTOR that does not work in the ORGANIZATION's FACILITY.
ON-SITE CONTRACTOR	1	S	A CONTRACTOR that works inside the ORGANIZATION's FACILITY.
ORGANIZATION	1	R	A Naval command, department or division.
OTHER PROPERTY	2	S	PROPERTY for which it is necessary to maintain its current location.
OUTGOING CORRESPONDENCE	4	R	Mail or message traffic that is originated by the ORGANIZATION.
PERSON	1	R	A person.
PHONE CALL	1	R	A phone conversation held by an EMPLOYEE. Usually long-distance calls.
PLAN OF THE WEEK	4	R	A weekly newsletter published by the ORGANIZATION.
POA&M	4	R	A plan of action to complete a goal.
PRODUCT	3	R	An item that is produced for a CUSTOMER.
PROPERTY	2	R	Equipment or items that are owned by the ORGANIZATION.

Entity Type Name	EERD Section	Entity Type	Description
QUALIFICATION	1	R	A skill that is held by EMPLOYEEs.
REFERENCE	4	R	An item that is used to hold information. Regulations, instructions and policies are all REFERENCEs.
SPECIAL PURCHASE	3	R	An item that is not a federal government standard stock supply.
STANDARD SUPPLY	3	R	Items that are federal government standard stock supplies.
SUPPLY LIST	3	R	The federal government standard stock supply list.
TRAVEL	1	R	A business trip taken by an EMPLOYEE.
TASK ORDER	3	R	A work order issued against a CONTRACT.
UNFUNDED REQUIREMENT	3	R	An item or project the ORGANIZATION wishes to buy or complete that does not have funding in the BUDGET.
VISITOR	1	S	A PERSON who visits the ORGANIZATION.
WG	1	S	A wage grade civil service EMPLOYEE.
WORK SCHEDULE	1	R	A schedule of an EMPLOYEE's working times.
WORK REQUEST	2	R	A request to repair a damaged FACILITY.

APPENDIX C

THE PROTOTYPE

This appendix contains the enhanced entity relationship model and one possible relational mapping of the prototype model developed for FLENUMOCEANCEN. The relational schema diagrammatic technique is that used by Kroenke and Dolan [Ref. 7:pp. 167-213]. A small number of attributes were chosen for the prototype:

- ORGANIZATION: Organization Code, Organization Name, UIC, Message Address, Street, City, State, Zip
- INCOMING CORRESPONDENCE: Serial Number, Originator, Standard Subject Identification Code, Subject, Date, Received Date
- DISTRIBUTION LIST: Keyword, Organization Code
- PLAN OF THE WEEK: Message, Start Message Date, Stop Message Date, Message Priority
- FACILITY: Facility Name, Facility Type
- PROPERTY: Serial Number, Property Type, Cost, Nomenclature
- PERSON: SSN, Last Name, First Name, Middle Name, Date of Birth
- EMPLOYEE: Office Phone Number
- VISITOR: Visit Start Date, Purpose of Visit, Visit Stop Date
- ACTIVE OFFICER: Rank, Designator
- GS: Series, Grade, Step
- FAMILY MEMBER: First Name, Relationship

This EER diagram uses a different labeling convention to display the cardinality ratio discussed in Chapter III. The numbers in the parentheses represent the minimum and maximum participation of the entity type in the relationship type [Ref. 1:p. 57]. This convention provides more information than using the 1, N and M. For example, in Figure 9, an organization may manage zero (0) to many (N) facilities. Zero in the minimum number of facilities an organization may manage with no upper limit set on the maximum number of facilities an organization may manage (N). A facility must be managed by one and only one organization.

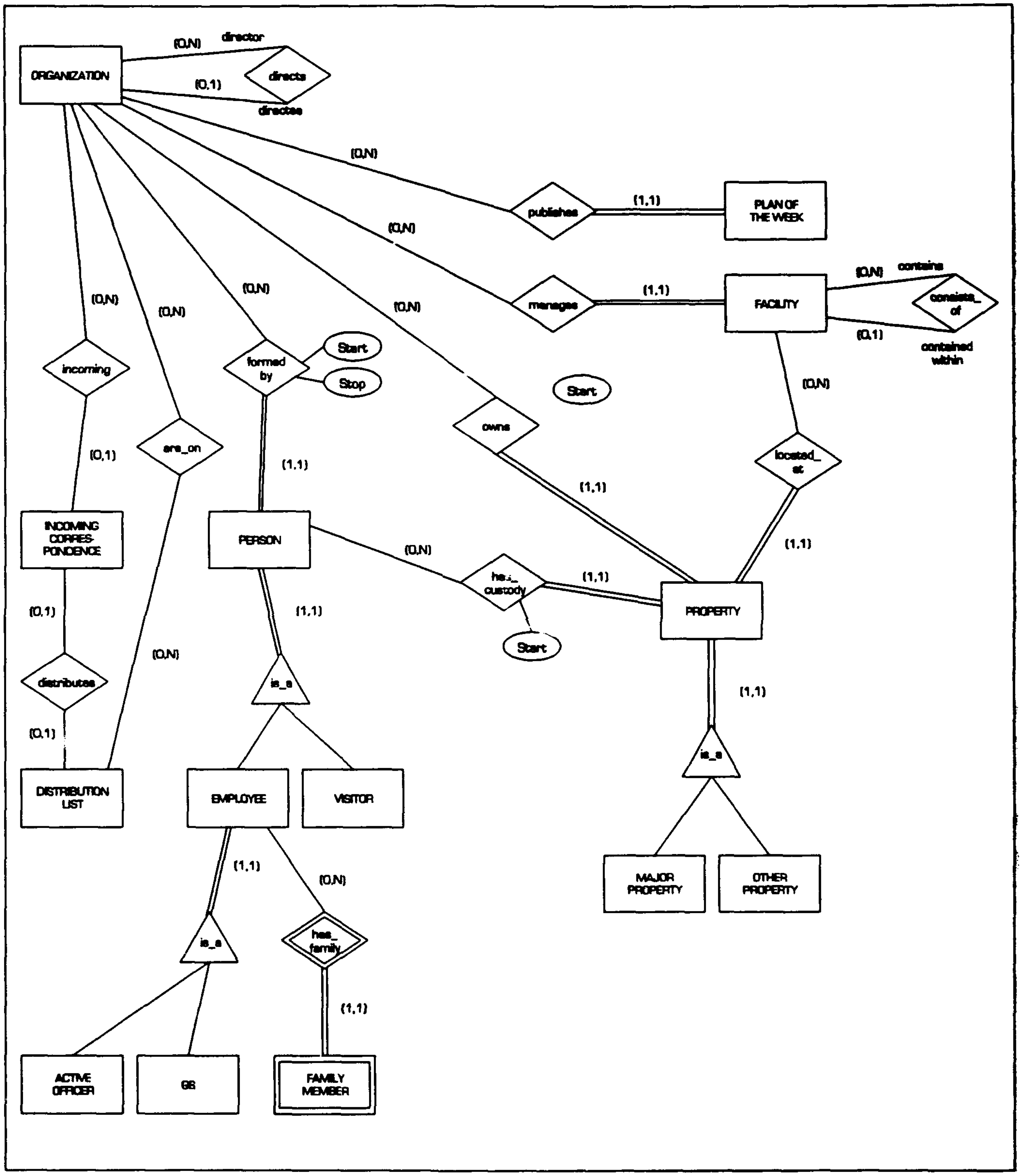

Figure 9. The Prototype EERD

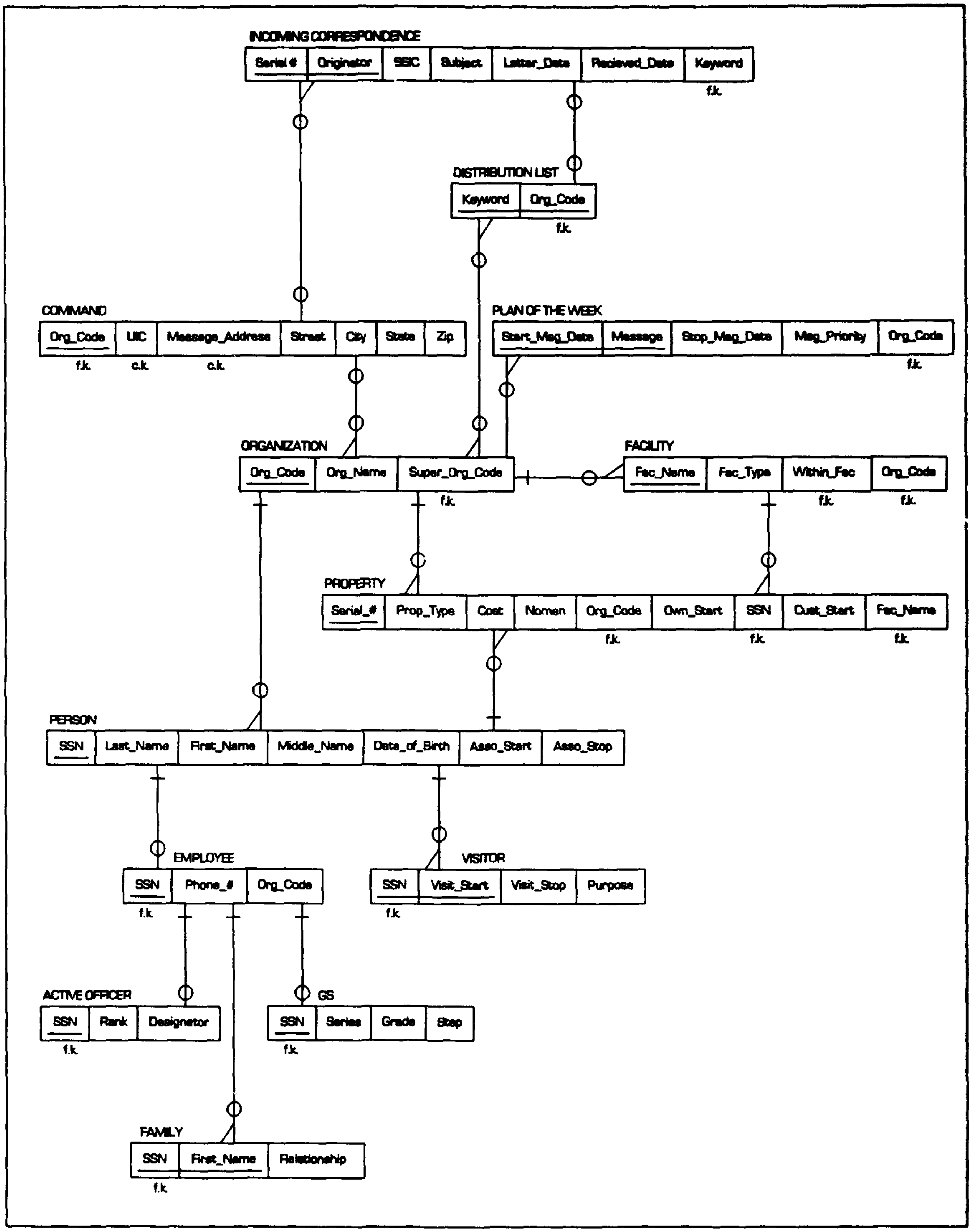

Figure 10. The Prototype Relational Schema

LIST OF REFERENCES

1. Elmasri, Ramez and Navathe, Shamkant B., *Fundamentals of Database Systems*, The Benjamin/Cummings Publishing Company, Inc., 1989.

2. McClanahan, David, "Database Design: Relational Rules," *DBMS*, v. 4, November 1991.

3. U.S. Department of Defense, *Trusted Computing Systems Evaluation Criteria*, DOD 5200.28-STD, December 1985.

4. *R:BASE Reference Manual*, 1st ed., June 1990.

5. *R:BASE User's Manual*, 1st ed., March 1990.

6. Interview between Commander Glenn D. Eberling, SC, USN, Naval Postgraduate School, Monterey, CA, and the author, 12 November 1991.

7. Kroenke, David M., and Dolan, Kathleen, *Database Processing: Fundamentals, Design, Implementation*, Science Research Associates, Inc., Chicago, IL, 1988.

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